VASCULAR FLORA AND EDAPHIC CHARACTERISTICS OF SALINE PRAIRIES IN LOUISIANA

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ABSTRACT

Saline prairies are unique, small-scale grassland communities found in the south-central United States. These grasslands occur on natric soils, which have high levels of exchangeable sodium, resulting in adverse physical properties including poor internal drainage and aeration. Subsurface natric horizons can contribute to harsh droughtiness. Landscape features within our study sites included broad flats, slicks, wet depressions, and pimple mounds. The flora of two study sites totaled 219 species and infraspecific taxa distributed among 148 genera and 65 families. Largest families were Poaceae, Cyperaceae, and Asteraceae with 39, 22, and 20 species, respectively. Exotic species totaled 17 (7.8%) and species rare at the state or global level totaled 20 (9.1%). *Geocarpon minimum*, which is federally-listed as threatened, was present at both study sites and was very abundant at one site. Our survey resulted in the discovery of two state records (*Lechea san-sabeana* and *Saxifraga texana*) and rediscovery in Louisiana of three taxa (*Carex arkansana*, *Gratiola flava*, and *Minuartia drummondii*). Soil pedon descriptions and chemical analyses confirmed the natric soil classification. Particle size analysis indicated that pimple mound soils were sandier than soils of other landscape positions, which were predominantly silty. Concentrations of Ca, Mg, and Na were elevated in broad flat and slick soils versus pimple mound soils. Surface horizons were mostly acidic with low sodium adsorption ratios (SAR) for most soil cores. Natric horizons were characterized by alkaline pH and SAR values often well above 15, and ranged in depth from 0 to 48 cm. We qualitatively relate flora to edaphic characteristics of each landscape position. Saline prairies at our study sites appear to be edaphically maintained as grasslands. We briefly discuss community classification in light of soils evidence.

RESUMEN

Las praderas salinas son comunidades herbáceas únicas a pequeña escala, que se encuentran en el sur-centro de los Estados Unidos. Estos herbazales se dan en suelos nátricos, que tienen niveles altos de sodio intercambiable, dando como resultado propiedades físicas adversas como drenaje y aireación interna pobres. Los horizontes nátricos del subsuelo pueden contribuir a una fuerte sequía. Las unidades de paisaje en nuestros lugares de estudio incluyeron llanuras, slicks, depresiones húmedas, y pimple mounds. La flora de dos lugares de estudio totalizó 219 especies y taxa infraspecíficos distribuidos en 148 géneros y 65 familias. Las familias más grandes fueron Poaceae, Cyperaceae, y Asteraceae con 39, 22, y 20 especies, respectivamente. Las especies exóticas fueron 17 (7.8%) y las especies raras a nivel estatal o global fueron 20 (9.1%). *Geocarpon minimum*, que está como amenazada en la lista federal, estaba presente en ambos sitios de estudio y era muy abundante en uno de ellos, Dalton/Dickson Saline Prairie. Nuestro estudio dio como resultado el descubrimiento de dos especies para el estado (*Lechea san-sabeana* y *Saxifraga texana*) y el redescubrimiento de tres taxa en Louisiana (*Carex arkansana*, *Gratiola flava*, y *Minuartia drummondii*). Las descripciones del suelo y análisis químicos confirman la clasificación nátrica del suelo. Los horizontes nátricos en las llanuras y slicks estaban en la superficie o muy cerca de ella, a una profundidad variable de 0 a 46 cm. El análisis del tamaño de partícula indicó que los suelos de los pimple mound eran más arenosos que los que estaban en otras posiciones, que eran predominantemente sedimentarios. Las concentraciones de Ca, Mg, y Na eran elevadas en los suelos de llanuras y slick a diferencia de los suelos de los pimple mound. Los horizontes superficiales eran acídicos con tasas bajas de absorción de sodio (SAR) en la mayoría de los núcleos de suelo. Los horizontes nátricos se caracterizaban por su pH alcalino y valores de SAR superiores a 15. Relacionamos cuantitativamente la flora con las características edáficas con cada unidad de paisaje. Las praderas salinas en nuestro lugar de estudio parecen estar mantenidas edáficamente como praderas. Discutimos brevemente la clasificación de la comunidad a la luz de las pruebas edáficas.

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INTRODUCTION

Saline prairies are typically small-scale natural grassland communities that occur on soils with unique chemical and physical properties (Louisiana Natural Heritage Program 2009b). Saline prairies occur in the West Gulf Coastal Plain of central and northwestern Louisiana, eastern Texas, and southern Arkansas (Louisiana Natural Heritage Program 2009b; NatureServe 2009), in the Arkansas River Valley of western Arkansas (Pittman 1993), and in the Mississippi River Alluvial Plain of eastern Arkansas (Arkansas Multi-Agency Wetland Planning Team 2001). In Louisiana, pre-settlement aerial coverage of saline prairies is estimated to have been fewer than 800 ha, with only 10 to 25 percent currently remaining (Lester et al. 2005). Threats to saline prairies include development and maintenance of roads and utility corridors, grazing practices, incompatible forestry practices, invasive species (e.g., feral pigs), oil and gas drilling, and vehicular traffic and recreational use (Lester et al. 2005). The community is currently considered globally imperiled with a rarity ranking of G1G2 (NatureServe 2009). Largely due to the presence of the federally-listed *Geocarpon minimum*, saline prairies are being studied floristically and edaphically (McInnis et al. 1993; Keith et al. 2004; Lester et al. 2005; Arkansas Natural Heritage Commission 2006; Diggs et al. 2006; MacRoberts et al. 2009b). The purpose of our study is to add descriptive floristic and edaphic information to the growing body of literature on saline prairies.

PHYSICAL SETTING, GEOLOGY, AND SOILS

Louisiana saline prairies occur on fluvial terraces adjacent to active floodplains. The soils formed in loamy late Pleistocene sediments (Soil Survey Staff 1991; Soil Survey Staff 1998) that correspond to the Prairie Terrace formation (Snead & McCullough 1984). The Prairie Terrace consists of reworked sediments that eroded from adjacent higher Pleistocene terraces and/or Tertiary formations (Huner 1939). The Prairie Terrace is the youngest and lowest in elevation of the Pleistocene terraces, and possibly formed during interglacial periods when sea level was high, thus reducing stream gradients and allowing deposition of fine sediments (Murray 1948). Three soil series are known to support saline prairies in Louisiana: Bonn, Brimstone, and Lafe. The following are taxonomic names for these soil series: Bonn series: fine-silty, mixed, superactive, thermic Glossic Natraqualfs; Brimstone series: fine-silty, siliceous, superactive, thermic, Glossic Natraqualfs; Lafe series: fine silty, mixed, active, thermic, Glossaquic Natrudalfs (Soil Survey Staff 2006). These are examples of natric soils, also called alkali, sodic, sodium, or solonetz soils (Horn 1962; Horn et al. 1964; Pettry et al. 1981; Soil Survey Staff 1998). Natric soils have a type of argillic horizon (containing illuviated clays) called a natric horizon that is characterized by high levels of exchangeable Na (≥ 15%) and by columnar/prismatic or blocky structure (Soil Survey Staff 2006). Natric soils are often associated with arid or semi-arid environments where low precipitation and high evaporation demand result in incomplete leaching of salts. Accumulation of Na in soils in humid environments has been attributed to interruption of leaching by impervious subsoil horizons (Smith 1937; Pettry & Switzer 1998). In natric horizons, soil hydraulic properties are degraded due to the dispersal of clay particles by Na^+. Dispersion of clay particles produces a natric horizon that is dense, compact, and slowly permeable to air and water (Smith 1937; Horn 1962, Hassett & Banwart 1992; Pettry & Switzer 1998). Physical properties of natric soils can reduce soil water storage and transport capacity resulting in droughty conditions (Rengasamy et al. 2003). The natric horizon functions like a claypan by perching water during wet periods, preventing upward movement of water during dry periods, and preventing plant roots from exploiting water deeper in the soil (Horn 1962; Pettry & Switzer 1998). Thus, soils are often either extremely dry or waterlogged, a condition described as xerohydric (NatureServe 2009). Hydrolysis of Na and formation of compounds such as NaOH and Na_2CO_3 result in strongly alkaline pH in natric horizons (Horn 1962). Natric soils have been the subject of considerable study due to the effects of their adverse physical properties on agricultural crop production (e.g., Shainberg et al. 1980; Rengasamy & Olsson 1991; Rengasamy et al. 2003; Vukadinović & Rengel 2007).

In studies of natric soils in eastern Arkansas and in Illinois, the weathering of Na-rich feldspars of the loess parent material was implicated as the source of Na (Wilding et al. 1963; Horn et al. 1964). Horn (1962) and Horn et al. (1964) suggest that possible sources of Na in non-loessal natric soils in Arkansas include incomplete leaching of salts adhering to flood-deposited sediments, and evaporation of salinized water that moves upward to the soil surface. The latter of these sources seems possible in saline prairies in central Louisiana, specifically in Winn Parish, where they often occur above large amounts of Jurassic Louann salt (Andrews 1960; Ingram 1991).

Depth to natric horizon is apparently important in determining soil physical and chemical properties and associated vegetation. In a study of natric soils in Arkansas, Horn et al. (1964) recognized soil groups based on depth to natric horizon, with the most extreme category being represented by the Lafe series, which in their study had a natric horizon within ~ 25 cm of the surface. Lafe soils were characterized by drought-tolerant species such as *Aristida* L. spp., *Opuntia* spp., and *Quercus stellata* (Horn et al. 1964).

The general appearance of a saline prairie is often pasture-like (Fig. 1). Saline prairies in Louisiana are open, usually with a short to medium-height grass canopy. The density of grasses is variable but is sparse relative to coastal and calcareous prairies, also found in Louisiana. We refer to the portions of the prairies with fairly continuous herbaceous cover as "broad flats." Broad flats account for the largest portions of saline prairies, the other landscape features usually being inclusional. Wet depressions are often embedded features in northwestern Louisiana saline prairies. These depressions tend to be shallow and support wetland plant species. Small "slicks" nearly devoid of vegetation occur where Na has been brought to the surface or where the natric horizon is very near the surface or exposed (Fig. 2). The soil surface within slicks often has a cryptogamic crust composed of algae, mosses, and lichens. Smaller slicks may be completely covered by this crust, while on larger slicks it may occur only along the margins. Pimple mounds (Fig. 3) are often scattered about and support trees and shrubs of various density, but are sometimes almost entirely open and grassy. Pimple mounds are enigmatic landscape features. Cain (1974) postulates that pimple mounds may have been formed by rill erosion occurring in a former climate characterized by alternating periods of drought and heavy rainfall. A more recent study provides evidence that pimple mounds are relict nebkhas, formed by deflation and subsequent deposition of soil by wind during prolonged droughts of the late Holocene period (Seifert et al. 2009). Seifert et al. (2009) point out that pimple mounds often coincide with claypan soils, which might have accentuated the effects of drought.

STUDY SITES AND METHODS

Starting in 2005, we began searching for saline prairies mainly in Caddo and DeSoto parishes in northwestern Louisiana. The Louisiana Natural Heritage Program database had no occurrence records of saline prairies for that region of the state at that time despite the relative commonness of Bonn silt loam in Caddo and De Soto parishes (Soil Survey Staff 1980; Soil Survey Staff 1991).

Using the soil surveys, Bonn soil map units were identified, and then located on 7.5' topographic maps and aerial photographs. Saline prairies and other inclusional prairies and barrens are often symbolized by irregular openings on topographic maps. The signature on dormant season ("leaf off") aerial photos is brownish gray, indicating that the herbaceous layer is composed of warm season species (dead at time photo was taken) rather than cool season (these would appear pinkish or reddish) (Fig. 4). Pimple mounds and depressions are often evident on aerial photos (Fig. 4). We examined soil surveys of parishes adjacent to areas containing Bonn soil map units as well and scanned the correct landscape position looking for irregular openings. Apparently Bonn soils or related soil series were overlooked in Bienville and Sabine Parishes. Confirmed saline prairies occur in these parishes on Guyton soils or map units containing the Guyton series in complex with other soils (Soil Survey Staff 1997; Soil Survey Staff 2001). Once potential saline prairies were identified, ownership of the sites was determined, and after gaining permission for access, the sites were visited for ground inspection. Since 2005, 10 new saline prairie occurrences have been documented (Louisiana Natural Heritage Program 2009a). Seven of these were discovered in Bienville, Caddo, De Soto, and Red River Parishes using the process described above. Three saline prairies were confirmed in Sabine Parish after being informed of their potential occurrence by a landowner and a colleague. Locations of extant

FIG. 1. Representative panoramic view of Barron Road Saline Prairie, Caddo Parish, Louisiana. Photo taken in July 2005.

FIG. 2. Slick in Dalton/Dickson Saline Prairie, De Soto Parish, Louisiana. Photo taken in October 2006.

FIG. 3. Pimple mounds in Dalton/Dickson Saline Prairie, De Soto Parish, Louisiana. Photo taken in May 2006.

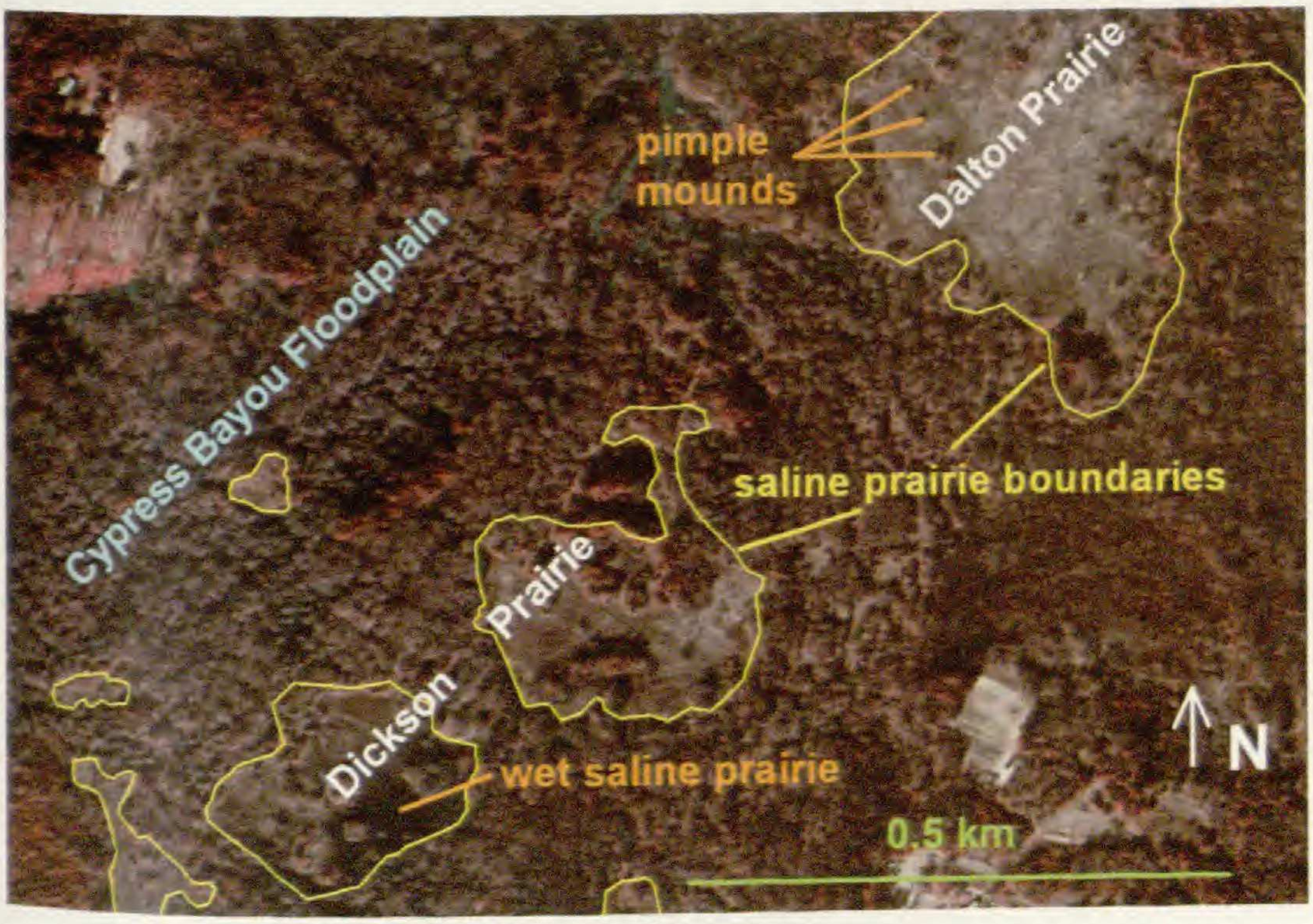

FIG. 4. 2004 dormant season, color infrared aerial photograph of portions of the Dalton/Dickson Saline Prairie complex, De Soto Parish, Louisiana.

saline prairies in Louisiana are presented in Figure 5. Cursory surveys were conducted at all sites to assess habitat quality and search for rare species. Two sites were more intensively studied and are the primary focus of this paper.

Barron Road Saline Prairie in southern Caddo Parish (32°21'13"N, 93°47'32"W) was discovered in July, 2005. This 6 ha site is situated just above the floodplain of Boggy Bayou, which empties into Wallace Lake. The prairie elevation is in the range of 46 to 49 m above sea level. The prairie is surrounded on its upland side by oak-pine-hickory woodlands and on its lowland side by bottomland hardwood forest that occupies the Boggy Bayou floodplain. Pimple mounds, measuring between 12 m and 33 m in diameter and <1 to 1.5 m high, are scattered over the prairie. Shallow wet depressions and slicks are occasional. The prairie has several roads through it and has been damaged by off-road vehicle use. At one time, establishment of loblolly pine (*Pinus taeda* L.) was attempted (S. Evans, pers. comm.); however, survival was extremely poor everywhere but on the pimple mounds, where even-aged, spindly trees have persisted.

Dalton/Dickson Saline Prairie, located in northern De Soto Parish (32°18'28"N, 93°48'24"W) about 5 km SSE of Barron Road Saline Prairie, consists of a complex of numerous small to large openings totaling 53 ha. It is positioned above the floodplain of Cypress Bayou, which also feeds into Wallace Lake. Most of the prairie openings are within 50 to 52 m in elevation. Pimple mounds and small wet depressions are scattered about. Much of this prairie complex is undisturbed and of very high quality. Portions do, however, experience off-road vehicle traffic. Establishment of rye grass (*Lolium perenne* L.) in one of the larger openings was attempted. Some rye grass persists in small scale patches.

The current climate of northwest Louisiana generally provides warm and humid summers and mild winters. Precipitation is fairly evenly distributed throughout the year and totals about 116 cm annually (Climate-Zone.com 2004).

FLORISTIC STUDY

Barron Road Saline Prairie was visited and voucher specimens collected every two to three weeks (except during the winter) between July 2005 and July 2006. Dalton/Dickson Saline Prairie was surveyed frequently during 2006 to search for rare plants, which were collected along with some additional species. A more thorough collection of plants from Dalton/Dickson Saline Prairie was made during regular visits from March to October 2007. Occasional collecting was carried out into 2009. Our collecting effort included species from all landscape features including broad flats, slicks, wet depressions, and pimple mounds. Scientific names follow Kartesz and Meacham (1999), Diggs et al. (2006), and USDA, NRCS (2009), in most cases. Voucher specimens are deposited at LSU and LSUS. To determine whether a species is native or exotic we consulted USDA, NRCS (2009). Using our checklist of species found at the study sites (native species only) and data from *Flora of North America* (1993–2007), Turner et al. (2003), NatureServe (2009), and USDA, NRCS (2009), we plotted the North American distribution of species by state, region, or province to determine geographic pattern and affinity.

SOIL COLLECTION AND ANALYSIS

In order to sample the intact soil profile, soil cores were taken at three relatively undisturbed saline prairie sites: Dalton/Dickson Saline Prairie, Rambin Bayou Saline Prairie (ca 12 km south of Dalton/Dickson) and Upper Weyerhaeuser Saline Prairie (a.k.a. Saline Creek Prairie) in Winn Parish, ca 145 km to the east (MacRoberts et al. 2009a). At each prairie, one soil core was extracted from broad flat, slick, and pimple mound landscape positions at subjectively determined locations within these sites. Upper Weyerhaeuser Prairie has no pimple mounds; thus only two cores were taken there, from broad flat and slick sites. The samples were separated into horizons with each horizon morphologically described at the time of collection. A soil sample from each horizon of each core was collected and stored in a plastic bag for further analyses. Soil samples from each horizon of each core were analyzed to determine basic chemical and physical attributes. Particle size analysis, pH, electrical conductivity (EC), cation exchange capacity (CEC), and sodium adsorp-

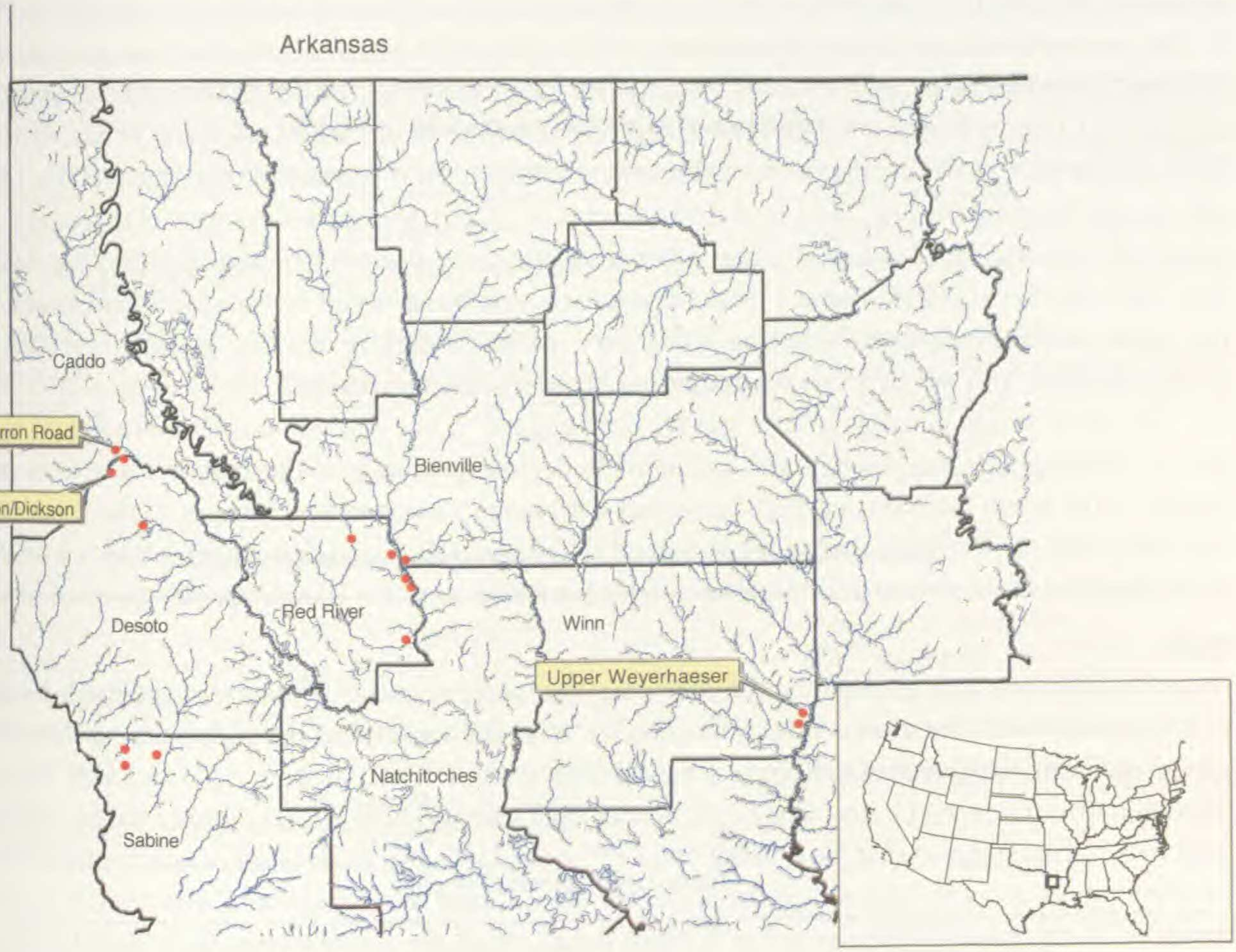

FIG. 5. Map showing locations of extant saline prairies in Louisiana.

tion ration (SAR) were determined by the Louisiana State University Coastal Wetlands Soils Characterization Lab (Wet Soils Lab). Particle size analysis was conducted for particles less than 2.0 mm. Soil samples were analyzed for sand content (0.05–2.0 mm), silt content (0.002–.05 mm), and clay content (<0.002 mm). Sand was separated by sieving. Clay content was determined using the pipette method. For pH and EC, soil samples were mixed in a 1:2 ratio (soil weight: water volume) and EC and salinity was read with an EC meter and pH with a pH meter. The 1:2 soil:water method for determining EC is a relatively inexpensive and quick method for getting an initial salinity estimate (Burt 2004). To get a more accurate measurement of EC, we re-sampled broad flat and slick soils at Rambin Bayou and Upper Weyerhaeuser Saline Prairies and analyzed each horizon for EC using the saturated paste method. For measurements of CEC and SAR, NH_4OAc was used as an extractant. CEC was determined by distillation and SAR by Inductively Coupled Plasma Mass Spectometry (ICP). Soil analyses performed by the Wet Soils Lab follow the *Soil Survey Laboratory Methods Manual* (Soil Survey Staff 1996). Soil nutrient analyses were performed by LSU Soil Testing and Plant Analysis Laboratory (LSU STPAL) using Mehlic 3 solution as an extractant (Mehlic 1984) and values reported are mehlic-extractable quantities.

RESULTS

Floristics

The saline prairie flora of both sites together included 219 species and infraspecific taxa distributed among 152 genera and 65 families (Appendix 1). Barron Road Saline Prairie had 130 species and Dalton/Dickson Saline Prairie supported 193. The two sites had 104 species in common. Poaceae was the most diverse family with 39 species. Cyperaceae and Asteraceae followed with 22 and 20 species, respectively. Exotic species accounted for 7.8% (17 taxa) of the total flora. Species rare at the global or state level totaled 20 (9.1%) (Table 2). The rarest globally are *Geocarpon minimum*, which is federally- listed as threatened and globally imperiled (G2), and *Schoenolirion wrightii*, which is globally rare (G3) (NatureServe 2009). *Geocarpon minimum* was very abundant at Dalton/Dickson Saline Prairie and rare at Barron Road (see MacRoberts & MacRoberts 2007, 2008, 2009a for monitoring data). Our field work resulted in the discovery of two state records, *Lechea sansabeana* and *Saxifraga texana* (Reid et al. 2007; Reid et al. 2008), and the rediscovery of three taxa that were previously historical for Louisiana: *Carex arkansana*, *Minuartia drummondii*, and *Gratiola flava* (MacRoberts et al. 2007; Reid et al. 2008). Table 1 lists characteristic species observed on each landscape position within the saline prairie complexes including broad flats, slicks (including broader sparsely-vegetated prairie), pimple mounds, and wet depressions (including broader-scale wet prairie).

The distribution of saline prairie species documented in our study is presented in Figure 6. Percentages of saline prairie species in states and regions decline gradually to the east and northeast and more steeply to the north and west beyond Texas and Oklahoma. One hundred percent of the taxa recorded at our study sites are found in Texas. Arkansas and Oklahoma followed Texas in percentages with 97 % and 92 %, respectively. Alabama and Mississippi both have 84% of saline prairie species reported herein.

Soils

Pedon descriptions may be found at the following web address: (www.wlf.louisiana.gov/soil-descriptions). In most cases, natric horizons are designated by an "n" suffix (e.g. Btn) in the pedon descriptions. However, the "n" suffix in horizon designations is not used with A and E horizons even if pH and SAR values qualify them as natric. The A and E horizons of slick cores from Dalton/Dickson and Rambin Bayou Saline Prairies were natric. This suggests that Na is being "wicked" to the surface in water and is concentrated at the surface by evaporation. A natric horizon in the slick core from Upper Weyerhaeuser Saline Prairie occurred at a depth of 28 cm. A natric horizon in the Rambin Bayou broad flat core was encountered at 13 cm, while in Dalton/Dickson and Upper Weyerhaeuser broad flat cores natric horizons first occurred at 46 and 25 cm, respectively. No natric horizons were encountered in the Dalton/Dickson pimple mound core. At Rambin Bayou, a natric horizon occurred at a depth of 48 cm in the pimple mound core.

Particle size distributions by landscape position are presented in Table 3. Broad flat and slick soils are in the silt loam textural class and pimple mound soil cores fall in the sandy loam textural class. There was a marked increase in clay content from E to Btn horizon in broad flat and pimple mound soil cores from Rambin Bayou Saline Prairie, and broad flat and slick cores from Upper Weyerhaeuser Saline Prairie (Table 3).

Mehlic-extractable Ca, Mg, and Na were elevated in the broad flat and slick cores compared to levels of these elements in the pimple mound cores (Table 4). Natric horizons are characterized by high pH and high SAR values (Table 4). Pimple mound soil horizons for Dalton/Dickson Saline Prairie are acidic throughout, while at Rambin Bayou, horizons were acidic until a depth of 48 cm where a natric horizon was encountered (Table 4). In broad flat cores, the upper horizons (A and E) were acidic to neutral, with subsurface horizons being alkaline (Table 4). As mentioned above, slick cores from Dalton/Dickson and Rambin Bayou were natric at the surface, the A and E horizons being alkaline and with high SAR values. Saturated paste EC values for each horizon of broad flat and slick cores from Rambin Bayou and Upper Weyerhaeuser Saline Prairies are presented in Table 4. For Upper Weyerhaeuser broad flat and slick cores, no horizon had an EC value that reached 2.0 mS cm^{-1}. For Rambin Bayou, the broad flat Btn1 and Btkn/E1 horizons had EC values of 2.204 and 2.27 mS cm^{-1}, respectively. The E1 and Btkn/E1 horizons in the Rambin Bayou slick core had respective EC values of 2.303 and 2.39 mS cm^{-1}. Electrical conductivity values of below 2.0 mS cm^{-1} are non-saline (Soil Survey Staff 1993). The horizons with EC values above 2.0 mS cm^{-1} fall in the "very slightly saline" category (Soil Survey Staff 1993).

DISCUSSION AND CONCLUSIONS

The only other comprehensive floristic study of a saline prairie that we are aware of was completed by MacRoberts et al. (2009a). Their study site was Upper Weyerhaeuser Prairie in north-central Louisiana,

Table 1. Characteristic plant species observed on various landscape positions within Barron Road and Dalton/Dickson Saline Prairies in northwest Louisiana. Species are listed alphabetically.

Broad Flats - areas with continuous herbaceous vegetation		
Aristida longespica	*Hordeum pusillum*	*Oenothera linifolia*
Aristida oligantha	*Houstonia* spp.	*Opuntia* sp.
Astragalus distortus var. *engelmannii*	*Hypericum drummondii*	*Phalaris caroliniana*
Coreopsis tinctoria	*Iva angustifolia*	*Ruellia humilis*
Croton willdenowii	*Krigia occidentalis*	*Schoenolirion wrightii*
Dichanthelium spp.	*Lechea tenuifolia*	*Sporobolus vaginiflorus* var. *vaginiflorus*
Evolvulus sericeus	*Minuartia drummondii*	*Sabatia campestris*
Fimbristylis puberula	*Minuartia muscorum*	*Saxifraga texana*
Gratiola flava	*Neptunia lutea*	*Tradescantia occidentalis*
Hedeoma hispida	*Nothoscordum bivalve*	
Slicks and sparsely-vegetated areas (inclusional to broad-scale)		
Anagallis minima	*Houstonia pusilla*	*Phemeranthus parviflorus*
Crassula aquatica	*Houstonia rosea*	*Plantago pusilla*
Dichanthelium oligosanthes ssp. *oligosanthes*	*Isolepis carinata*	*Rumex hastatulus*
Geocarpon minimum	*Krigia occidentalis*	*Schedonnardus paniculatus*
Gratiola flava	*Lepuropetalon spathulatum*	*Sporobolus pyramidatus*
Houstonia micrantha	*Oenothera spachiana*	
	Opuntia sp.	
Pimple Mounds (inclusional)		
Andropogon ternarius	*Lechea san-sabeana*	*Rhynchospora harveyi*
Chrysopsis pilosa	*Marshallia caespitosa*	*Schizachryium scoparium*
Dichanthelium sphaerocarpon var. *sphaerocarpon*	*Panicum brachyanthum*	*Sideroxylon lanuginosa*
Digitaria cognata	*Paspalum setaceum*	*Tradescantia hirsutiflora*
Helianthemum rosmarinifolium	*Pinus echinata*	*Vaccinium arboreum*
Ilex vomitoria	*Pinus taeda*	
	Quercus margaretta	
Wet Depressions (inclusional to broad-scale)		
Baccharis halimifolia	*Isoetes melanopoda*	*Limnosciadium pinnatum*
Carex arkansana	*Juncus acuminatus*	*Ludwigia* spp.
Eleocharis wolfii	*Juncus brachycarpus*	*Sagittaria papillosa*
Euthamia leptocephala	*Juncus dichotomus*	*Steinchisma hians*
Helenium flexuosum	*Juncus marginatus*	*Tridens strictus*

approximately 145 km to the southeast of Barron Road and Dalton/Dickson Saline Prairies. Upper Weyerhaeuser Saline Prairie was much smaller than our sites and was notably uniform, lacking landscape features such as pimple mounds and wet depressions. It had 59 species, of which 44 (~75%) also occur at Barron Road and Dalton/Dickson Saline Prairies (MacRoberts et al. 2009a). A comparison of the flora of Upper Weyerhaeuser Prairie with that of our study sites shows that some species were conspicuous at one site and not the others. For example, *Bigelowia nuttallii* L.C. Anderson, a species characteristic of rocky glades, barrens, and eroded soils, was very common on Upper Weyerhaeuser Saline Prairie and absent from our study sites. *Opuntia* sp. was very common on our study sites and absent from Upper Weyerhaeuser Saline Prairie. (Note: species identification of our *Opuntia* material is premature pending further systematic study [L. Majure, pers. comm.].)

MacRoberts et al. (2009a) remarked that saline prairies and sandstone glades/outcrops share a number of species. In their study of three sandstone outcrops in west-central Louisiana, MacRoberts & MacRoberts

Table 2. Rare plant species documented within Barron Road and Dalton/Dickson Saline Prairies in Caddo and De Soto Parishes, Louisiana. Global and state ranks range from 1 to 5 with 1 being the most rare and 5 being demonstrably secure. Global ranks are from NatureServe (2009) and state ranks are from Louisiana Natural Heritage Program (2010).

Family	Scientific Name	Global Rank	State Rank	Comments
Amaryllidaceae	*Cooperia drummondii*	G5	S2	First records from saline prairies in Louisiana, previous records being from coastal and calcareous prairies.
Asteraceae	*Diaperia verna*	G5	S1	Apparently first record from a natural community in Louisiana, other records being from lawns and cemeteries.
Asteraceae	*Pterocaulon virgatum*	G5	S2	Elsewhere in coastal prairies and on pimple mounds in *Pinus palustris* Mill. flatwoods in southwest Louisiana.
Caryophyllaceae	*Geocarpon minimum*	G2	S2	Federally listed as threatened, one of five occurrences in Louisiana where it is restricted to saline prairies (Reid et al. 2008).
Caryophyllaceae	*Minuartia drummondii*	G5	S2	Previously historical in Louisiana (MacRoberts et al. 2007).
Caryophyllaceae	*Minuartia muscorum*	G4	S3	This element may prove to be more common in Louisiana.
Cistaceae	*Helianthemum rosmarinifolium*	G4	S2	Extant populations in Louisiana are on pimple mounds in saline prairies.
Cistaceae	*Lechea san-sabeana*	G4	S1	State record (Reid et al. 2008).
Cyperaceae	*Carex arkansana*	G4	S1	Previously known in Louisiana from one historical specimen (Reid et al. 2008).
Cyperaceae	*Eleocharis wolfii*	G3G4	S3	Global status is reviewed by McKenzie et al. (2009).
Fabaceae	*Lotus unifoliolatus*	G5	S2	Other Louisiana records are from beside railroads and thus are possibly introduced.
Grossulariaceae	*Ribes curvatum*	G4	S2	Recorded from Caddo and Desoto Parishes where it is known from mesic hardwood or mixed loblolly pine-hardwood forests.
Hyacinthaceae	*Schoenolirion wrightii*	G3	S2	In Louisiana restricted to saline prairies and sandstone glades.
Hydrophyllaceae	*Phacelia glabra*	G4	S2	Known in Louisiana from saline prairies in Bienville, Caddo, and Desoto Parishes and from an "open field" in Ouachita Parish.
Nyctaginaceae	*Mirabilis albida*	G5	S2	In Louisiana mostly known from sandhills and calcareous prairies.
Oleaceae	*Forestiera ligustrina*	G4G5	S3	Known elsewhere from northwest Louisiana from mixed hardwood-loblolly pine and hardwood slope forests.
Poaceae	*Schedonnardus paniculatus*	G5	S1	There are few other Louisiana occurrences, from calcareous and possibly coastal prairies.
Portulacaceae	*Phemeranthus parviflorus*	G5	S3	In Louisiana restricted to saline prairies and sandstone glades.
Saxifragaceae	*Saxifraga texana*	G4	S1	State record (Reid et al. 2007)
Scrophulariaceae	*Gratiola flava*	G4	S1	Previously historical in Louisiana (MacRoberts et al. 2007)

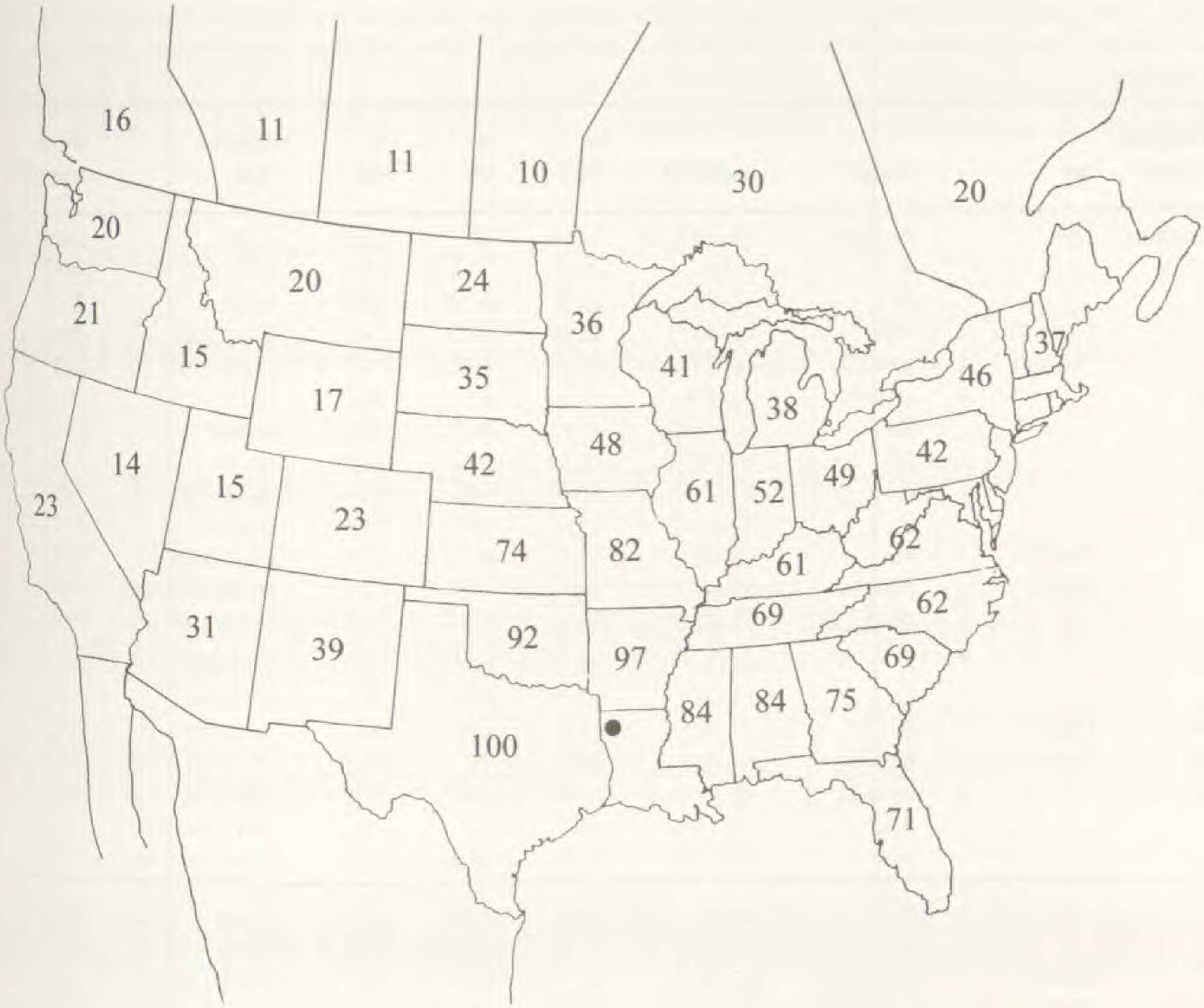

Fig. 6. Map showing North American distribution of saline prairie flora documented at Barron Road and Dalton/Dickson Saline Prairies in northwest Louisiana. Each number is a percentage of the saline prairie flora that occurs in the particular state, province, or region.

(1993) reported 136 taxa. Of these, 46 taxa are also found in our study sites. Species reported from sandstone outcrops that were conspicuous at Dalton/Dickson and Barron Road Saline Prairies include *Aristida longispica*, *A. oligantha*, *Croton willdenowii*, *Dichanthelium aciculare*, *Evolvulus sericeus*, *Fimbristylis puberula*, *Hedeoma hispida*, *Phemeranthus parviflorus*, *Sabatia campestris*, and *Schoenolirion wrightii* (MacRoberts & MacRoberts 1993).

Coastal and calcareous prairies are characteristically dominated by perennial grasses including *Andropogon gerardii* Vitman, *Schizachyrium scoparium*, *Sorghastrum nutans* (L.) Nash, and *Panicum virgatum* L.. (MacRoberts et. al. 2009b; Allen et al. 2001). Of these, *S. scoparium* is a component of the saline prairie flora. Though often conspicuous on pimple mounds, *S. scoparium* was not a dominant species of broad flats in our study sites. In our study sites, the most conspicuous grasses in broad flats, which accounted for the largest area of any landscape position, were *Aristida longespica*, *A. oligantha*, and *Sporobolus vaginiflorus* var. *vaginiflorus*. These species are fall-flowering annuals. They are widespread and occur in a variety of habitats including disturbed areas, dry fields, roadsides, and waste places (Grass Phylogeny Working Group and Allred 2003; Peterson et al. 2003). These species were conspicuous in undisturbed parts of our study sites. Perhaps these disturbance-tolerant species were abundant in our saline prairies because they are exploiting the available growing space provided by relatively sparse vegetative cover and taking advantage of seasonally exposed soil.

Table 3. Soil particle size distribution and organic matter (OM%) for each horizon of soil cores taken from broad flat, slick, and pimple mound landscape positions from Barron Road, Dalton/Dickson, and Upper Weyerhaeuser Saline Prairies in Louisiana.

Landscape Position	Site	Horizon	Depth (cm)	% Sand	% Silt	% Clay	Textural Class	Organic Matter (%)
Position	Site	Horizon	Depth (cm)	Sand	Silt	Clay	Class	Matter (%)
		A	0–13	39.2	50.3	10.5	Silt Loam	2.76
		E1	13–25	27.3	47.9	24.8	Loam	2.97
	Dalton/	Btk1	25–46	26.1	44.7	29.2	Clay Loam	4.09
	Dickson	Btkn/E1	46–79	22.6	45.8	31.6	Clay Loam	4.27
B		Btkn/E2	79–104	30.3	43	26.7	Loam	3.43
R		Btk	104–132	37.1	41.2	21.7	Loam	2.75
O		BC	132–158	43.1	39.1	17.8	Loam	2.32
A		A	0–8	50.8	44.8	4.4	Sandy Loam	1.89
D		E1	8–13	35.3	49.1	15.6	Loam	2.12
	Rambin	Btn1	13–69	31.2	41	27.7	Clay Loam	3.42
	Bayou	Btkn/E1	69–99	38.5	34.5	27	Loam/Clay Loam	2.87
		Btn/E2, BC	99–223	64.9	21.9	13.2	Sandy Loam	1.39
F		A	0–13	34	62.1	3.9	Silt Loam	2.01
L		E1	13–25	31	61.5	7.5	Silt Loam	1.87
A	Upper	Btn/E1	25–53	17.1	62.4	20.5	Silt Loam	2.75
T	Weyerhaeuser	Btng/E1	53–86	20.7	55	24.3	Silt Loam	2.87
		Btng/E2	86–135	22.6	54.8	22.6	Silt Loam	2.65
		BCg	135–190	5.9	65	29.1	Silty Clay Loam	3.50
		Cg1	190–213	11.8	56.8	31.4	Silty Clay Loam	3.69
		A	0–15	33.6	39.5	26.9	Loam	3.26
		Btn1	15–43	41.8	35.6	22.6	Loam	2.97
	Dalton/	Btgn/E1	43–81	61.3	25.7	13	Sandy Loam	1.95
	Dickson	Btgn/E2	81–127	65.8	24.2	10	Sandy Loam	1.51
		2C	127–157	84	13.1	2.9	Loamy Sand	0.74
S		A and E1	0–36	24.5	50.6	24.9	Silt Loam	3.26
L		Btkn/E1	36–101	22.7	45.3	32	Clay Loam	4.41
I	Rambin	2BC	101–152	53.3	28.8	17.9	Sandy Loam	2.53
C	Bayou	2C	152–218	67.3	19.9	12.8	Sandy Loam	1.57
K		A	0–8	15.7	70.2	14.1	Silt Loam	2.32
		BE	8–28	6.1	68.3	25.6	Silt Loam	3.53
	Upper	Btng/E1	28–51	5.1	71.2	23.7	Silt Loam	3.12
	Weyerhaeuser	Btng/E2	51–89	5.5	71.7	22.8	Silt Loam	2.95
		Btkng/E3	89–127	6.9	65.1	28	Silty Clay Loam	3.59
		Btkng/E4	127–160	9.1	58.4	32.5	Silty Clay Loam	3.78
P		A	0–15	57.6	37	5.4	Sandy Loam	2.82
I		E1	15–46	53	41.1	5.9	Sandy Loam	1.87
M	Dalton/	E2	46–61	53.4	40.7	5.9	Sandy Loam	1.50
P	Dickson	Bt/E1	61–84	53.5	43	3.5	Sandy Loam	0.91
L		Bt/E2	84–119	49.3	43.9	6.8	Sandy Loam	0.88
E		Btg1	119–157	44.9	38.4	16.7	Loam	1.85
		A, E1, E2	0–23	54.2	42.1	3.7	Sandy Loam	2.37
M	Rambin	E3	23–48	48.5	49	2.5	Sandy Loam	0.75
O	Bayou	Btn1, Btn2	48–111	34.9	47	18.1	Loam	2.16
U		Btn, E1	111–144	29.9	41.3	28.8	Clay Loam	3.49
N		Btn/E2, BC	144–221	59.09	23.5	17.36	Sandy Loam	2.56
D								

TABLE 4. Mehlic-extractable nutrients (Ca, Mg, Na), pH, cation exchange capacity (CEC), sodium adsorption ratio (SAR), and electrical conductivity (EC) for each horizon of soil cores taken from broad flat, slick, and pimple mound landscape positions from Barron Road, Dalton/Dickson, and Upper Weyerhaeuser Saline Prairies in Louisiana.

Landscape Position	Site	Horizon	Depth (cm)	Ca (mg kg⁻¹)	Mg (mg kg⁻¹)	Na (mg kg⁻¹)	pH (1:2)	CEC (cmol kg⁻¹)	SAR	EC (Saturated Paste) (mS cm⁻¹)	EC (1:2 soil:water) (mS cm⁻¹)
		A	0–13	394.4	122.6	127.4	5.45	6.48	1.5	—	0.1
		E1	13–25	542.1	266.4	962.5	5.94	11.99	7.7	—	0.2
	Dalton/	Btk1	25–46	692.1	418.4	1779	6.02	18.04	12.1	—	0.3
	Dickson	Btkn/E1	46–79	876.7	603.1	2548	8.08	20.38	18.1	—	0.3
B		Btkn/E2	79–104	703.1	551.2	2348.1	8.72	17.09	16.7	—	0.4
R		Btk	104–132	1016.8	471.4	1992	9.12	13.72	11.8	—	0.5
O		BC	132–158	1930.8	431	1755.6	9.26	12.54	9.2	—	0.6
A		A	0–8	201.5	75.8	63.9	5.7	2.21	3.1	0.1	0.1
D		E1	8–13	208.8	108.8	1077.4	6.98	6.04	16.7	1	0.2
	Rambin	Btn1	13–69	669.3	435.9	3305.3	9.41	16.75	43.8	2.2	0.7
	Bayou	Btkn/E1	69–99	686.5	311.7	3407.7	9.65	15.99	53	2.3	0.8
		Btn/E2, BC	99–223	793.6	188.5	1546.1	9.62	8.49	14.2	Btn/E2 - 1.7 BC - 1.0	0.5
F		A	0–13	245.8	78.5	121.8	6.88	2.39	1.6	0.7	0.1
L		E1	13–25	246.9	129.3	449.6	7.17	4.5	5.9	0.3	0.1
A	Upper	Btn/E1	25–53	362.9	301.1	1721.4	8.32	11.04	15.2	1.4	0.2
T	Weyerhaeuser	Btng/E1	53–86	414.7	366.7	2136.1	8.6	12.59	18.2	1.5	0.3
		Btng/E2	86–135	406.8	339.3	1961.3	8.57	12.4	16.8	1.4	0.2
		BCg	135–190	569	421.3	2403.2	8.71	17.97	20.6	1.4	0.3
		Cg1	190–213	668.4	454.4	2606.7	8.84	17.54	17.2	1.7	0.3
		A	0–15	692.3	446.1	2425.1	8.51	16.3	21.4	—	0.3
		Btn1	15–43	487.6	349.5	2330.2	9.31	13.58	13.7	—	0.5
	Dalton/	Btgn/E1	43–81	812.2	213.9	1552.3	9.51	8.04	12.5	—	0.4
	Dickson	Btgn/E2	81–127	198.8	121.3	1187.3	8.72	6.97	16.4	—	0.1
		2C	127–157	196.2	81	327.9	8.21	2.37	13.2	—	0
S		A and E1	0–36	1115.8	377.1	2979.6	9.52	12.97	32.7	A – 1.2; E1 - 2.3	0.8
L	Rambin	Btkn/E1	36–101	816.8	307.4	4557.2	9.71	19.33	96	2.4	0.8
I	Bayou	2BC	101–152	464.7	141.9	2506.2	9.53	12.81	43.8	1.6	0.4
C		2C	152–218	620.8	159.1	1432.7	9.26	8.1	19.7	(sample too small)	0.2
K		A	0–8	429.3	270.1	844.2	6.41	7.83	7.6	0.6	0.3

Table 4. continued.

Landscape Position	Site	Horizon	Depth (cm)	Ca (mg kg^{-1})	Mg (mg kg^{-1})	Na (mg kg^{-1})	pH (1:2)	CEC (cmol kg^{-1})	SAR	EC (Saturated Paste) (mS cm^{-1})	EC (1:2 soil:water) (mS cm^{-1})
		BE	8–28	691.9	558.3	2039.2	8.07	16.48	14.2	1.6	0.3
	Upper	Btng/E1	28–51	563.6	482	2054.7	8.73	15.53	15.6	1.4	0.3
	Weyerhaeuser	Btng/E2	51–89	483.3	406.3	2133.8	9.02	14.87	18.9	1.7	0.3
		Btkng/E3	89–127	764.5	404.9	2532.3	9.04	16.49	20.6	1.5	0.4
		Btkng/E4	127–160	1008.9	429.7	2765.4	8.95	19.01	21.7	1.6	0.6
P		A	0–15	157	33.6	15.9	4.85	4.34	0.5	—	0
I		E1	15–46	76.8	21.5	6.6	4.48	3.03	0.5	—	0
M	Dalton/	E2	46–61	63.6	20.5	12.4	4.71	2.75	1.1	—	0
P	Dickson	Bt/E1	61–84	52.5	19.6	19	5.2	1.4	2.1	—	0
L		Bt/E2	84–119	53.9	50.7	263.9	6.27	2.07	8.7	—	0
E		Btg1	119–157	92.3	115.5	782.9	6.08	6.99	14.9	—	0.1
		A, E1, E2	0–23	309.9	23.4	15.9	4.78	2.75	4	—	0
M	Rambin	E3	23–48	63.7	22.6	47.3	5.62	0.71	8.8	—	0
O	Bayou	Btn1, Btn2	48–111	221.1	168.4	1790.4	8.41	8.33	24.4	—	0
U		Btn, E1	111–144	312.7	279.2	3082.1	9.01	14.31	51.3	—	0
N		Btn/E2, BC	144–221	624.383	217.532	2170.21	9.51	10.88	25.9	—	0
D											

A conspicuous floristic component of saline prairies consists of late-winter and spring ephemerals that complete their reproductive cycle while there is adequate moisture. During winter and spring months, moisture is abundant in the upper soil horizons as rainfall is plentiful and evapotranspiration is low. These ephemeral species usually disappear by May or June (earlier in some cases). Examples of such species include *Anagallis minima*, *Crassula aquatica*, *Coreopsis tinctoria*, *Geocarpon minimum*, *Gratiola flava*, *Houstonia* spp., *Krigia dandelion*, *Krigia occidentalis*, *Minuartia drummondii*, *Minuartia muscorum*, *Phacelia glabra*, *Sabatia campestris*, *Schedonnardus paniculatus*, and *Scutellaria parvula*.

As the summer sets in, soils of the broad flats and slicks become drier and harder as water in the A and E horizons is depleted by evapotranspiration. Drought tolerant species such as *Iva angustifolia*, *Opuntia* sp., *Mirabilis albida*, and *Phemeranthus parviflorus* are often the only plants in broad flats and slicks that are in good condition during the hottest summer months.

The pimple mound flora includes species that would be expected in dry to sub-xeric sandy soils of pine or hardwood dominated woodlands elsewhere in the West Gulf Coastal Plain. Examples of such species include *Alophia drummondii*, *Andropogon ternarius*, *Digitaria cognata*, *Ilex vomitoria*, *Panicum brachyanthum*, *Quercus margaretta*, *Schizachyrium scoparium*, and *Vaccinium arboreum*. *Pinus taeda* seedlings and saplings were relatively frequent on pimple mounds of our study sites. Mature *P. taeda* were rare. Some seedling and sapling mortality was noted but the cause was not diagnosed. Drought stress is a possibility. Mature trees on pimple mounds were most frequently *Quercus margaretta*, and often these trees were of large diameter, short height, and were twisted and possibly very old.

The soil analyses confirmed the natric horizon characterizations previously described for both the Bonn and Brimstone soil series (Soil Survey Staff 2006; Soil Survey Staff 1998; Soil Survey Staff 1991; Soil Survey Staff 1980). Soil textural data from the extracted cores underscored the differences between landscape positions. Pimple mounds were notably sandier than the broad flats and slicks, while the silt component dominated the broad flat and slick cores (Table 3).

The surface horizons in our study sites, with the exception of slicks, were acidic with low SAR values (Table 4). Obligate halophytic species are lacking in our study sites. Based on personal observation at our study sites and elsewhere, *Sporobolus pyramidatus* could be considered halophytic. In our study areas it was restricted to and common on slicks. Peterson et al. (2003) report *S. pyramidatus* to occur in "disturbed soils, roadsides, railways, coastal sands, and alluvial slopes in many plant communities." *Iva angustifolia* is a very conspicuous herb on broad flats. Habitat accounts for *Iva angustifolia* by Gandhi and Thomas (1989) and Strother (2006) indicate that it grows in disturbed areas, waste places, and overgrazed pastures, with no mention of saline or natric soils. Since this species colonizes areas impacted by oilfield brine (personal observation), it might be considered a facultative halophyte. It appears that the vegetation of saline prairies is largely controlled by the influence of the natric subsurface horizons on soil moisture content and availability, rather than chemical characteristics in the plant rooting zone.

The community name "saline prairie" has been used by Louisiana Natural Heritage Program (2009b), Keith et al. (2004), Lester et al. (2005), MacRoberts et al. (2009a) and McInnis et al. (1993), among others. Saline soils have high levels of dissolved salts, the concentration of which is measured by electrical conductivity (Hassett & Banwart 1992). Natric soils do not have excessive concentrations of dissolved salts but rather have high concentrations of exchangeable Na. While salinity will negatively impact sensitive plants, the adverse physical characteristics of natric soils are not necessarily present in saline soils (Hassett & Banwart 1992). The sodium adsorption ratio (SAR) is considered the standard measure of soil sodicity (Soil Survey Staff 1993). This ratio also takes into account the comparative concentrations of calcium and magnesium ions that tend to moderate the adverse effects of Na. Sodium adsorption ratio values above 12 to 15, combined with alkaline pH, identify a natric horizon (Table 4). For many subsurface horizons from our broad flat and slick cores, SAR values exceed the threshold range, and in some cases, greatly so (Table 4). Depending on texture, natric soils can become extremely sticky when wet and almost impermeable to surface water. When dry they can be very hard and resist wetting. In both cases, plants will have difficulty obtaining soil water. Our analysis of soil cores for saturated paste EC shows that a few subsurface horizons from one site are very slightly saline according to Soil Survey Staff (1993) and soils at the other study site are completely non-saline. Hassett and Banwart (1992) consider soils to be saline if EC is 4 mS/cm or higher, well above EC values in our data. Thus, applying the term "saline" to the natural community name may be misleading. Arkansas Multi-Agency Wetland Planning Team (2001) avoids this inaccuracy by applying the name "Alkali Flat," which accounts for the natric soils and generally flat topography.

The floristics and edaphic traits of saline prairies are the principal factors that define these natural community systems. Based on the International Vegetation Classification (IVC) system, NatureServe (2009) places saline prairies and the associated saline oak woodlands within the South-Central Saline Glade ecosystem (CES203.291). This glade ecosystem is broken down into several vegetation associations with four prairie associations and one woodland association known from Louisiana. The most frequently identified association in Louisiana is the *Artistida longespica* Poir. – *Schizachyrium scoparium* – *Diodia teres* Saline Herbaceous Vegetation (CEGL008419), and it seems to be most closely matching association for saline prairies in northwest Louisiana. This association was described based principally on saline prairies in Arkansas, and therefore some differences in plant species occur for the Louisiana prairies. For example, *Schizachyrium scoparium*, *Diodia teres*, and *Sabal minor* while present, are not dominants in Louisiana examples we have studied.

The historical role of fire in saline prairies is not known. Sparse vegetative cover may have reduced the role of fire in these systems (NatureServe 2009). Extreme soil properties and droughty conditions are apparently sufficient to maintain prairies in our study sites, which have no threat of woody encroachment. While prairies studied by us appear to be edaphically extreme enough to prevent woody encroachment and to maintain a grassland community, fire may have been very important in adjacent communities and thus important in a broader landscape context.

Studies of floristics and edaphics of additional saline prairies throughout the range of the community would expand information on geographic variation and enable refinement of the natural community classification. Quantitative sampling of vegetation and edaphic variables in random or systematically placed plots would enable correlations of vegetation to soils on a fine scale. This type of procedure may reveal important factors determining the vegetation composition, density, and coverage in saline prairies that are not apparent with our broader floristic approach.

There is a wet-variant saline prairie that is sometimes adjacent to the saline prairie community described in this paper (Louisiana Natural Heritage Program 2009b). These prairies occur on lower landscape positions, experience regular inundation, and support halophytes more characteristic of coastal localities such as *Atriplex cristata* Humb. & Bonpl. ex Willd., *Distichlis spicata* (L.) Greene, *Heliotropium curassavicum* L., and *Solidago sempervirens* L. (Smith 1996). In Louisiana, *Spartina pectinata* Bosc ex Link is almost entirely restricted to wet-variant saline prairies. Wet-variant saline prairies are in need of similar baseline floristic and edaphic study.

APPENDIX 1. CHECKLIST OF SPECIES

Species recorded from Barron Road Saline Prairie (B) and Dalton/Dickson Saline Prairie (D). Key to voucher specimens: CR = Christopher Reid, whose specimens are deposited at LSU; MM = B.R. and M.H. MacRoberts, whose specimens are deposited at LSU and LSUS. If there is no mention of landscape position, broad flats is intended. Species of slicks are treated as occurring in broad flats in this list. Table 1 lists characteristic species of each landscape position, including slicks. Rare species are denoted with a dagger (†). State- or globally-rare species are summarized in Table 2, where conservation status ranks are provided. Exotic species are denoted with an asterisk (*).

Acanthaceae

Justicia ovata (Walt.) Lindau var. *lanceolata* (Chapm.) R. W. Long—D, wet depressions, MM 7816

Ruellia humilis Nutt.—B D, broad flats and pimple mounds, CR 5931, MM 7245, 7447, 7954

Alismataceae

Sagittaria papillosa Buchenau—D, wet depressions, MM 7728, 7887

Alliaceae

Allium canadense L. var. *mobilense* (Regel) M. Ownbey—B D, MM 7354, 7384 (observed but not collected at D)

Nothoscordum bivalve (L.) Britt.—B D, MM 7292, 7604

Amaryllidaceae

†*Cooperia drummondii* Herbert—B D, CR 5655, MM 7247 (observed but not collected at D)
Habranthus tubispathus (L'Hér.) Traub—B D, CR 5598, MM 7246 (observed but not collected at D)

Anacardiaceae

Rhus copallinum L.—B, pimple mounds, MM 7260

Apiaceae

Daucus pusillus Michx.—D, pimple mounds, CR 7001
Limnosciadium pinnatum (DC.) Mathias & Constance—B D, broad flats and wet depressions, CR 6129, 6982, MM 7403, 7414, 7421, 7749, 7774, 7799
Ptilimnium nuttallii (DC.) Britt.—B D, pimple mounds, broad flats, and wet depressions, CR 6174, MM 7422, 7444, 7800
Trepocarpus aethusae Nutt. ex DC.—B, MM 7440

Aquifoliaceae

Ilex vomitoria Ait.—B, pimple mounds, CR 7199, MM 7261

Aracaceae

Sabal minor (Jacq.) Pers.—D, broad flats and wet depressions, CR 6180, MM 7355, 7947

Aspleniaceae

Asplenium platyneuron (L.) B.S.P.—D, pimple mounds, CR 6994

Asteraceae

Baccharis halimifolia L.—B D, wet depressions and pimple mounds, MM 7270 (observed but not collected at D)
Boltonia diffusa Ell.—B, MM 7436
Chrysopsis pilosa Nutt.—B D, pimple mounds, MM 7450, 7818, 7875
Coreopsis lanceolata L.—D, broad flats edges (upslope), CR 6986
Coreopsis tinctoria Nutt.—B D, CR 6065, MM 7407, 7797, 7750
†*Diaperia verna* (Raf.) Morefield (= *Evax verna* Raf.)—D, CR 6077
Erigeron tenuis Torr. & A. Gray—B D, CR 6996, MM 7337, 7383
Euthamia leptocephala (Torr. & A. Gray) Greene—B D, CR 5926, MM 7464
**Facelis retusa* (Lam.) Sch. Bip.—D, pimple mounds, MM 7617
Gamochaeta argyrinea Nesom—B, MM 7433
Helenium flexuosum Raf.—B D, wet broad flats, CR 7019, MM, 7419
Iva angustifolia Nutt. ex DC.—B D, CR 5661, 5925, MM 7404, 7463, 7939, 8047
Iva annua L.—D, CR 6750, MM 7870, 8048
Krigia dandelion (L.) Nutt.—B D, MM 7299, 7328 (observed but not collected at D)
Krigia occidentalis Nutt.—B D, CR 6005, MM 7300, 7598
Liatris aspera Michx.—D, pimple mounds, CR 5835
Marshallia caespitosa Nutt. ex DC.—B D, pimple mounds, CR 5723, 6988, MM 7351, 7378

†*Pterocaulon virgatum* (L.) DC.—D, pimple mounds, CR 5927
Pyrrhopappus carolinianus (Walt.) DC.—B D, CR 7018, MM 7416
Symphyotricum pratense (Raf.) Nesom—B, MM 7283

Brassicaceae

Lepidium densiflorum Schrad.—D, CR 6124, MM 7754
Lepidium virginicum L.—B D, MM 7326, 7334, 7379, 7606

Buddlejaceae

Polypremum procumbens L.—D, pimple mounds, MM 8050

Cactaceae

Opuntia Mill. sp.—B D, CR s.n., MM 7396, 7768 (Note: species identification in our *Opuntia* material is premature and warrants further systematic study [L. Majure, pers. comm.])

Callitrichaceae

Callitriche pedunculosa Nutt. (=*C. nuttallii* Torr.)—B, MM 7306

Campanculaceae

Lobelia appendiculata A. DC.—B D, pimple mounds, CR 7000, MM 7400
Triodanis perfoliata (L.) Nieuwl.—B D, CR 5734, MM 7350, 7380, 7746

Caryophyllaceae

**Cerastium glomeratum* Thuill.—B D, MM 7323, 7335, 7605
†*Geocarpon minimum* Mackenzie—B D, CR 5995, 6003, MM 7284, 7585
†*Minuartia drummondii* (Shinners) McNeill—B D, CR 5721, MM 7308, 7586, 7615
†*Minuartia muscorum* (Fassett) Rabeler—B D, CR 5712, 5720, 6013, MM 7309, 7317, 7331, 7612, 7723

Cistaceae

†*Helianthemum rosmarinifolium* Pursh—B D, pimple mounds, CR 5770, 5776, MM 7431, 7401, 7739, 7804
†*Lechea san-sabeana* (Buckley) Hodgdon—B D, pimple mounds, CR 6064 (TEX-LL), 6179, MM 7738, 7824, 7827, 7828, 7832, 7834
Lechea tenuifolia Michx.—B D, broad flats and pimple mounds, CR 6176, MM 7829, 7822, 7823, 7951

Clusiaceae

Hypericum drummondii (Grev. & Hook.) Torr. & A. Gray—B D, CR 5662, 6126, MM 7250, 7462, 7356, 7446, 8052
Hypericum gentianoides (L.) B.S.P.—D, MM 7874
Hypericum hypericoides (L.) Crantz—B, pimple mounds, MM 7262

Commelinaceae

Tradescantia hirsutiflora Bush—B D, broad flats and pimple mounds, CR 7016, MM 7348, 7602, 7730
Tradescantia occidentalis (Britt.) Smyth—B D, CR 6075, MM 7346, 7347, 7755, 7603

Convolvulaceae

Dichondra carolinense Michx.—D, pimple mounds, CR 6995
Evolvulus sericeus Sw.—B D, CR 5658, 6135, MM 7279, 7376, 7753

Crassulaceae

Crassula aquatica (L.) Schoenl.—B D, CR 5996, MM 7303, 7589

Cupressaceae

Juniperus virginiana L.—D, pimple mounds, CR 5781, MM 8121, 7760

Cuscutaceae

Cuscuta gronovii Willd. ex Schult.—D, CR 5923, MM 8053

Cyperaceae

†*Carex arkansana* Bailey—D, wet depressions, CR 5748
Carex bushii Mack.—B, MM 7389
Carex complanata Torr. & Hook.—D, pimple mounds, CR 7017
Carex crus-corvi Shuttleworth ex Kunze—D, wet broad flats, CR 5766
Carex lupulina Muhl. ex Willd.—D, wet broad flats, CR 5765
Cyperus acuminatus Torr. & Hook. ex Torr.—B D, wet depressions and pimple mounds MM 7434, 7767, 7889
Cyperus echinatus (L.) Alph. Wood—D, MM 7885 (mixed sheet with *C. retroflexus*)
Cyperus pseudovegetus Steud.—D, wet depressions, CR 7014, MM 7811, 7770
Cyperus retroflexus Buckley—D, MM 7885 (mixed sheet with *C. echinatus*)
Cyperus retrorsus Chapm.—D, wet depressions, pimple mounds, and broad flats, CR 6144, MM 7812, 7892, 7958
Cyperus squarrosus L. (=*C. aristatus* Rottb.)—D, MM 7955
Cyperus strigosus L.—D, broad flats edges, CR 7193
Eleocharis tenuis (Willd.) Schult. var. *verricosa* (Svenson) Svenson—B, MM 7338
Eleocharis ambigens Fernald—D, wet depressions, MM 7765, 7772
†*Eleocharis wolfii* (A. Gray) A. Gray ex Britt.—B D, wet depressions, CR 6080, 6083, 6980, 6981, MM 7722
Fimbristylis puberula (Michx.) Vahl—B D, CR 6128, 6140, MM 7256, 7305, 7320, 7388, 7743, 7744, 7798
Isolepis carinata Hook. & Arn. ex Torr.—B D, MM 7297, 7597
Rhynchospora corniculata (Lam.) A. Gray—D, wet depressions, MM 7776, 7880
Rhynchospora caduca Ell.—D, wet depressions, CR 5779
Rhynchospora globularis (Chapm.) Small var. *globularis*—B D, pimple mounds and wet depressions, CR 6137, MM 7724, 7428
Rhynchospora harveyi W. Boott—B D, pimple mounds, CR 5596, 5739, 6177, 7024, MM 7427
Scleria ciliata Michx.—B D, CR 5777, MM 7395

Ericaceae

Vaccinium arboreum Marsh.—B D, pimple mounds, CR 6130, MM 7263, 7758, 8118

Euphorbiaceae

Acalypha gracilens A. Gray—D, pimple mounds, CR 5922
Chamaesyce maculata (L.) Small—D, MM 7945
Croton capitatus Michx.—B D, broad flats and pimple mounds, CR 6751, MM 7448, 7868
Croton willdenowii G.L.Webster—B D, broad flats and pimple mounds, CR s.n., 5666, 6757, MM 7267, 7449, 7807, 7881
Euphorbia spathulata Lam.—B D, MM 7382 (observed but not collected at D)

Fabaceae

Astragalus distortus Torr. & A. Gray var. *engelmannii* (E. Sheld.) M.E. Jones—B D, CR 6002, MM 7289, 7599
Chamaecrista fasciculata (Michx.) Greene—B D, broad flats and pimple mounds, CR 5775, MM 7282, 7795, 7432
Gleditsia triacanthos L.—D, MM 7442, 7759
**Kummerowia striata* (Thunb.) Schindl.—D, pimple mounds, MM 7946
Lathyrus pusillus Ell.—B D, CR 6926, MM 7333
Lespedeza repens (L.) Bart.—D, pimple mounds, CR 5778
†*Lotus unifoliolatus* (Hook.) Benth.—B, MM 7373, 7397
**Medicago lupulina* L.—D, MM 7601
Mimosa strigillosa Torr. & A. Gray—B D, MM 7257, 7949
Neptunia lutea (Leavenworth) Benth.—B D, CR 5758, MM 7249, 7735, 7796
Strophostyles leiosperma (Torr. & A. Gray) Piper—D, broad flats and pimple mounds, CR 6175, MM 7802, 7886, 7820

Fagaceae

Quercus margaretta Ashe—B D, pimple mounds, CR 6756, 7194, 7196, MM 7258
Quercus phellos L.—B, pimple mounds, MM 7248
Quercus similis Ashe—D, CR 6136, 7025, 7195, 7197, 7200
Quercus stellata Wang.—D, broad flats and pimple mounds, MM 7763

Gentianaceae

Sabatia campestris Nutt.—B D, CR 6127, MM 7415, 7742, 7805, 7806

Grossulariaceae

†*Ribes curvatum* Small—D, pimple mounds, CR 6016

Haloragaceae

Myriophyllum pinnatum (Walt.) B.S.P.—D, wet depressions, CR 7026, MM 7737, 7877

Hyacinthaceae

†*Schoenolirion wrightii* Sherman—B D, CR 5693, 5715, MM 7291, 7315, 7343, 7398, 7595

Hydrophyllaceae

†*Phacelia glabra* Nutt.—B D, broad flats and pimple mounds, CR 5692, 5722, MM 7327, 7607

Iridaceae

Alophia drummondii (Graham) R.C. Foster—D, pimple mounds, CR 7012
Sisyrinchium atlanticum E. P. Bicknell—D, MM 7726
Sisyrinchium langloisii Greene—B, MM 7329, 7330
**Sisyrinchium rosulatum* E. P. Bicknell—B D, CR 6989, MM 7344

Isoetaceae

Isoetes melanopoda Gay & Durieu ex Durieu—B D, wet depressions, MM 7293, 8496

Juncaceae

Juncus acuminatus Michx.—D, wet depressions, CR 5763, 5768, 6139, 7013, MM 7775

Juncus brachycarpus Engelm.—B D, wet broad flats, CR 5773, MM 7394, 7424

**Juncus capitatus* Weigel—D, broad flats and pimple mounds, CR 7022, MM 7594

Juncus dudleyi Wiegand—B D, wet depressions, CR 5738, 5772, MM 7409, 7766

Juncus dichotomus Elliott—B D, wet broad flats, CR 7015, MM 7387

Juncus marginatus Rostk.—D, pimple mounds and wet broad flats, CR 5762, 5774, 7004, 7021, MM 7809

Juncus secundus P. Beauv. ex Poir.—D, wet broad flats, CR 7020

Luzula bulbosa (Alph. Wood) Smyth & Smyth—B D, broad flats and pimple mounds, CR 5714, MM 7319, 7608

Lamiaceae

Hedeoma hispida Pursh—B D, CR 6066, MM 7352, 7377, 7748, 7944

Physostegia intermedia (Nutt.) Engelm. & A. Gray—D, wet depressions, CR 5735, MM 7769

Prunella vulgaris L.—D, broad flats edges, CR 6987

Scutellaria integrifolia L.—B, pimple mounds, MM 7399

Scutellaria parvula Michx.—B, pimple mounds, MM 7324

Linaceae

Linum medium (Planch.) Britt. var. *texanum* (Planch.) Fern.—B D, broad flats and pimple mounds, CR 5740, MM 7412, 7425, 7808

Loganiacaeae

Gelsemium sempervirens (L.) St.-Hil.—B, pimple mounds, MM 7290

Lythraceae

Ammania coccinea Rottb.—D, wet depressions, MM 7810, 7941

Nyctaginaceae

†*Mirabilis alba* (Walt.) Heimerl—D, CR 5742, 5832, 5924, 6754

Oleaceae

†*Forestiera ligustrina* (Michx.) Poir.—D, pimple mounds, CR 5991, 6131, 7204

Fraxinus pennsylvanica Marsh.—D, pimple mounds, MM 7762

**Ligustrum sinense* Lour.—D, pimple mounds, CR 7201

Onagraceae

Ludwigia alternifolia L.—D, wet depressions, MM 7817

Ludwigia glandulosa Walt.—D, wet depressions, CR 5760

Ludwigia peploides (Kunth) Raven—D, wet depressions, MM 7878, 7948

Oenothera laciniata Hill—D, MM 7741, 7803

Oenothera linifolia Nutt.—B D, CR 6068, MM 7353, 7616, 7745

Oenothera spachiana Torr. & A. Gray.—D, CR 6015, 6072, 6067

Ophioglossaceae

Botrychium lunarioides (Michx.) Sw.—D, CR 6925

Orchidaceae

Spiranthes vernalis Engelm. & A. Gray—B, MM 7435, 7430

Oxalidaceae

Oxalis corniculata L.—D, MM 7609, 7813

Oxalis dillenii Jacq.—B, MM 7336

Pinaceae

Pinus echinata Mill.—D, pimple mounds, MM 7814

Pinus taeda L.—B D, pimple mounds, MM 7265, 7761, 7815 (observed but not collected at D)

Plantaginaceae

Plantago aristata Michx.—B D, CR 6141, 7023, MM 7405, 7740, 7752

Plantago pusilla Nutt.—B D, MM 7301, 7332, 7611

Plantago virginica L.—B D, CR 6997, MM 7302, 7393

Poaceae

Agrostis elliottiana Schult.—B D, CR 5718, MM 7325, 7596

Agrostis hyemalis (Walt.) B.S.P.—B D, CR 5771, MM 7418

**Aira caryophyllea* L.—D, CR 5743, MM 7593

**Aira elegans* Willd.—D, CR 6014, MM 7729

Andropogon ternarius Michx.—D, broad flats and pimple mounds, CR 5983, MM 7884, 7950, 8044, 8120

Aristida longespica Poir.—B D, CR 5645, 5648, 5649, 5650, 5652, 5988, 5657; MM 7274

Aristida oligantha Michx.—B D, CR 5651, 5989, MM 7251, 7940, 8119

**Briza minor* L.—B D, CR 6134, MM 7349, 7747

**Bromus racemosus* L.—D, broad flats edges, CR 6983

**Cynodon dactylon* (L.) Pers.—B D, CR 6178, MM 7385, 7757

Dichanthelium aciculare (Desv. ex Poir.) Gould and C.A. Clark—B D, CR 5716, 5737, MM 7391, 7392, 7402

Dichanthelium acuminatum (Sw.) Gould & C.A. Clark subsp. *lindheimeri* (Nash) Freckmann & Lelong—D, CR 6071

Dichanthelium dichotomum (L.) Gould & C.A. Clark ssp. *roanokense* (Ashe) Freckmann & Lelong—B, MM 7420, 7406

Dichanthelium oligosanthes (Schultes) Gould ssp. *oligosanthes*—D, CR 5744

Dichanthelium scoparium (Lam.) Gould—B D, MM 7438 (observed but not collected at D)

Dichanthelium sphaerocarpon (Ell.) Gould var. *sphaerocarpon*—B D, broad flats and pimple mounds, CR 5736, MM 7252

Digitaria cognata (J.A. Schultes) Pilger—B D, pimple mounds, CR 5647, 5834, 6761, MM 7281

Eragrostis lugens Nees—B D, CR 5646, 6753, MM 7253

Eragrostis secundiflora J. Presl.—D, CR 5833, 5984, 6762, MM 7882, 8045

Hordeum pusillum Nutt.—B D, CR 6081, MM 7390, 7732

**Lolium perenne* L.—D, CR 6985, MM 7756

Panicum brachyanthum Steud.—D, pimple mounds, CR 5831, MM 8049

Paspalum floridanum Michx.—D, pimple mounds, CR 7198

Paspalum setaceum Michx.—B D, CR 5653, 6759, MM 7280, 7423

Phalaris caroliniana Walt.—B D, broad flats and pimple mounds, CR 6078, MM 7374, 7731

†*Schedonnardus paniculatus* (Nutt.) Trel.—D, CR 5747, MM 7411, 7872

Schizachyrium scoparium (Michx.) Nash—B D, broad flats and pimple mounds, CR 5990, MM 7271, 8051
Setaria parviflora (Poir.) Kerguélen—B D, CR 6758, MM 7266, 7952
**Setaria pumila* (Poir.) Roem. & Schult. subsp. *pallidefusca* (Shumach.) B.K. Simon—B, MM 7443
Sphenopholis filiformis (Chapm.) Scribn.—D, CR 6079
Sporobolus compositus (Poir.) Merr. var. *macer* (Trin.) Kartesz & Gandhi—D, pimple mounds, CR 5932, 6752, 6760
**Sporobolus indicus* (L.) R. Br.—D, CR 5759
Sporobolus pyramidatus (Lam.) A.S. Hitchc.—B D, CR 5654, 5660, 5780, 5928, 6125, MM 7277, 7437, 7873
Sporobolus vaginiflorus (Torr. ex A. Gray) Alph. Wood. var. *vaginiflorus*—B D, CR 5659, 5987, MM 7272
Steinchisma hians (Ell.) Nash—B D, broad flats and wet depressions, CR 6138, MM 7268, 7254, 7773, 7888, 7956
Tridens flavus (L.) Hitchc. var. *flavus*—D, broad flats edges, CR 6755
Tridens strictus (Nutt.) Nash—B D, wet depressions, CR 5985, MM 7269, 7891, 7942
Urochloa platyphylla (Munro ex C. Wright) R. D. Webster—B D, MM 7275 (observed but not collected at D)
Vulpia octoflora (Walt.) Rydb.—D, CR 6133, 6998

Polygonaceae
**Polygonum aviculare* L.—B, CR 5665
Polygonum hydropiperoides Michx.—D, wet depressions, CR 5761, MM 7771, 7871
Polygonum ramosissimum Michx.—B D, MM 7445, 7821, 7876
Rumex hastatulus Baldw.—B D, CR 5717, 6143, MM 7298, 7592

Portulacaceae
Claytonia virginica L.—B D, CR 5997, MM 7294, 7610
†*Phemeranthus parviflorus* (Nutt.) Kiger (= *Talinum parviflorum* Nutt.)—B D, CR 5593, 5725, MM 7255, 7278, 7413, 7751

Potamogetonaceae
Potamogeton diversifolius Raf.—D, wet depressions, MM 7736

Primulaceae
Anagallis minima (L.) Krause—B D, MM 7307 (observed but not collected at D)

Ranunculaceae
Anemone caroliniana Walt.—D, CR 5998
Delphinium carolinianum Walt.—D, pimple mounds, CR 6992
Ranunculus fascicularis Muhl. ex Bigelow—D, pimple mounds, MM 7590
**Ranunculus sardous* Crantz—B D, CR 6991, MM 7318

Rosaceae
Rubus louisianus Berger (= *R. argutus* Link)—B, pimple mounds, MM 7372
Rubus trivialis Michx.—B, pimple mounds, MM 7426

Rubiaceae
Diodia teres Walt.—B D, CR 5662, MM 7801, 7869, 7943
Galium tinctorium (L.) Scop.—B, MM 7345, 7386
Houstonia micrantha (Shinners) Terrell—B D, CR 5999, MM 7288, 7614
Houstonia pusilla Schoepf—B D, MM 7286, 7617b
Houstonia rosea (Raf.) Terrell—B D, CR 6000, MM 7287

Rutaceae
Zanthoxylum clava-herculis L.—D, pimple mounds, CR 7202, MM 7727

Sapotaceae
Sideroxylon lanuginosum Michx.—B D, broad flats and pimple mounds, CR 6142, MM 7264, 7591, 7725

Saxifragaceae
Lepuropetalon spathulatum Ell.—B D, MM 7304 (observed but not collected at D)
†*Saxifraga texana* Buckley—D, CR 6001, MM 8123

Scrophulariaceae
Agalinis heterophylla (Nutt.) Small ex Britt.—D, MM 8046
†*Gratiola flava* Leavenworth—B D, CR 5724, 6004, 6009, MM 7285, 7312, 7584
Gratiola virginiana L.—D, wet depressions, MM 7733
Nuttallanthus canadensis (L.) D. A. Sutton—B D, CR 6082, 6993, MM 7295, MM 7600

Smilacaceae
Smilax rotundifolia L.—B, pimple mounds, MM 7276

Solanaceae
Solanum carolinense L.—B, pimple mounds, MM 7417

Ulmaceae
Ulmus alata Michx.—B D, pimple mounds, CR 6132, 7203, MM 7259
Ulmus crassifolia Nutt.—D, pimple mounds, MM 7764

Valerianaceae
Valerianella radiata (L.) Dufr.—B D, CR 6076, MM 7321, 7322, 7613

Verbenaceae
Verbena halei Small—D, CR 6999, MM 7819, 7879

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